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Macronutrients and Micronutrients Relation to Soil Characteristics of Wellington Reservoir, Tamilnadu, India.

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ABSTRACT

Soil is vital resources in which proper use depends on the country and the socio-economic development of its people. Macronutrients (N,P, and K) and micronutrients (Zn,Fe,Cu and Mn) are essential for healthy plant growth. N,P, K are needed in large amounts and Zn,Fe,Cu and Mn are needed in smaller amounts. Both macronutrients and micronutrients are naturally obtained by the roots from the soil. Correlation analysis was carried out by using bivariate correlation using Pearson's method. This was carried out for macronutrients and micronutrients dataset and it indicates geochemical complexity in the region with less negative correlation of all parameter. About 30 soil samples were collected around the tank irrigated watershed of wellington reservoir and analyzed for the macronutrients and micronutrients. The analyzed samples were classified based on standard methods. A study of the nutrient status of soils of Tittakudi taluk (Tamilnadu) was made at different locations. The experiment was to study the status of macronutrients and micronutrients and their relationship with various physico-chemical properties. The values of pH and electrical conductivity indicated that most of the soils are neutral to modal alkaline in nature and non-saline in nature. Almost all samples were found to be deficient in nitrogen while the remaining macronutrients varying from low to high levels. 21 samples were containing high amount of available micronutrients depending on iron. The study concludes that most of the micronutrients of soil samples fall in sufficient category and few of them indicate low suitability for agriculture purposes. Therefore

in the study area, the soils with deficit nutrients have to be treated well before using for agriculture purposes.

Keywords: Correlation analysis, physicochemical properties, Soil criteria, Soil quality and Soil nutrients.

I. INTRODUCTION

Agriculture continues to be the most predominant sector of the Indian economy, as 70% of the population is engaged in agriculture and allied activities for their livehood. Plants are the immense example of autotroph mechanism. Photosynthesis is a source of energy for virtually all of the organisms on the Earth. Survival and reproduction of plants require water, air, light and relatively considerable amounts of nutrients called essential nutrients to carry out photosynthesis and thus produce energy (Wiedenhoeft, 2006). To get the benefit from the crop plant we have to protect them from various kind of stress, especially nutrient stress (deficiency). Plant cannot synthesize required nutrient, so the nutrients are extracted from soil medium and loaded into the plant parts and which finally entered into the food chain. So soil fertility is one of the important factors controlling yields of the crops. Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in context of sustainable agriculture production. Because of imbalanced and inadequate fertilizer use coupled with low efficiency of other inputs, the response (production) efficiency of chemical fertilizer nutrients has declined tremendously under intensive agriculture in recent years. Soil provides ecosystem services critical for life: soil acts as a water filter and a growing medium; provides habitat for billions of organisms, contributing to biodiversity; and supplies most of the antibiotics used to fight diseases. Humans use soil as a holding facility for solid waste, filter for wastewater, and foundation for our cities and towns. Soil organic matter offers several added benefits: it filters and cleans water, enhances water retention and storage, mitigates the impacts of extreme weather events, improves soil structure, reduces soil erosion, provides microbial habitats, and serves as a source of long-term, slow-release nutrients.

Today, comparatively more rainfed (60%) area under cultivation, however in future such poor soils would be brought under cultivation due to population pressure (Rego *et al.*, 2005). Therefore, we need to create massive awareness and develop model strategy to get the maximum benefits of micronutrients on crop yield and quality and that can be readily accepted by farmers and consumers. Micronutrient deficiencies in soil not only limit the crop production but it also has negative effects on human nutrition and health. The WHO has estimated that over 3 billion people in the world suffer from micronutrient malnutrition and that about 2 billion people of these have a Fe deficiency (WHO, 2002; Long *et al.*, 2004). In Asia about 35% of children between 0-5 years of age suffer from Fe and Zn deficiency. It affects large segment of population mostly women, infants and children in resource poor families in the country (Singh *et al.*, 2009).Prevalence of anemia in pregnant women is the highest in

India due to deficiency of iron. The several elements known to be essential for plant growth, macronutrients (N, P, and K) and micronutrients (Zn, Fe, Cu, Mn) are important soil elements that control its fertility. The aim of this study was to evaluate available nutrient status and their relationship with soil properties. One representative soil sample was taken from each development taluk of Tittkudi.

Soil Series and Characteristics

It was found that there are 6 soil series in Tittakudi. The name of the 6 soil series and its occupied percentages are Red soil 35%, Black soil 60.5%, alluvial soil 3.48%, Red loamy soil 0.7%, Sandy soil 1.06% and Sandy loaming soil 0.17%. The entire area of Western pediplainsare covered by Mangalur and Nallur blocks. This area is occupied by denudational landforms like shallow buried pediment, deep buried pediment and pediments. Black soils are observed in the Vriddhachalam taluks (CGWB 2009).

II. THE STUDY AREA

The study area considered is Wellington reservoir watershed which is located in the Tittakudi taluk. It lies between the longitudes of 11˚13' to 11˚33' E and latitudes of 77˚26' to 77˚56'N (Fig 1). Tittagudi is a panchayat town and taluk headquarter of Cuddalore district, Tamilnadu, India. As of 2001 India Census, Tittagudi had a population of 20,734. In this taluk, agriculture area is 823.74 km^2 and mean annual rainfall is 1110mm. Black soil is the predominant soil type in this area and main occupation of the area is agriculture. The groundwater level of the study area ranges from 2m to 8m bgl (below ground level). The Reservoir is located in Vellar Basin across a tributary stream Periya Odai of Vellar River. It receives Regulated Supply diverted from Vellar River at Tholudur Regulator and an additional catchment area of 129 $(km)^2$ of its own during North East Monsoon. The Reservoir was constructed during 1913-1923 and irrigates an ayacut of 11,200 Hectare. Paddy, Sugarcane are the major crops grown in and around wellington ayacut.The Reservoir was formed with available earth at site which was not suitable for the formation of Reservoir such formation with nonsuitable soil leads lot of problems such as slips etc., year by year.

III. METHODOLOGY

Soil samples (0-20 cm depth) were collected from 30 sites from the distance of every 5km interval. (Fig.1) covering 30 revenue villages, keeping in view the physiographic characteristic indifferent cross sections of the area as well as variation in soil texture. The list of villages of sampling sites of Tittakudi Taluk soils are highlighted in Fig 1. The names of the sampling stations are given below in correspondence to the number on the map. The processed soil samples were analyzed for basic soil parameters (pH, EC and calcium carbonate) and for macronutrients (N,P,K) by using standard procedures (Jackson 1973). The available Fe, Mn, Cu and Zn in soil samples were extracted with a DTPA solution (0.005M DTPA + 0.01 M CaCl2 + 0.1 Mtriethanolamine, pH 7.3) as outlined by Lindsay and Norvell (1978). The concentration of micronutrients in the extract was determined by atomic absorption-spectrophotometer (ECIL, AAS-4129).

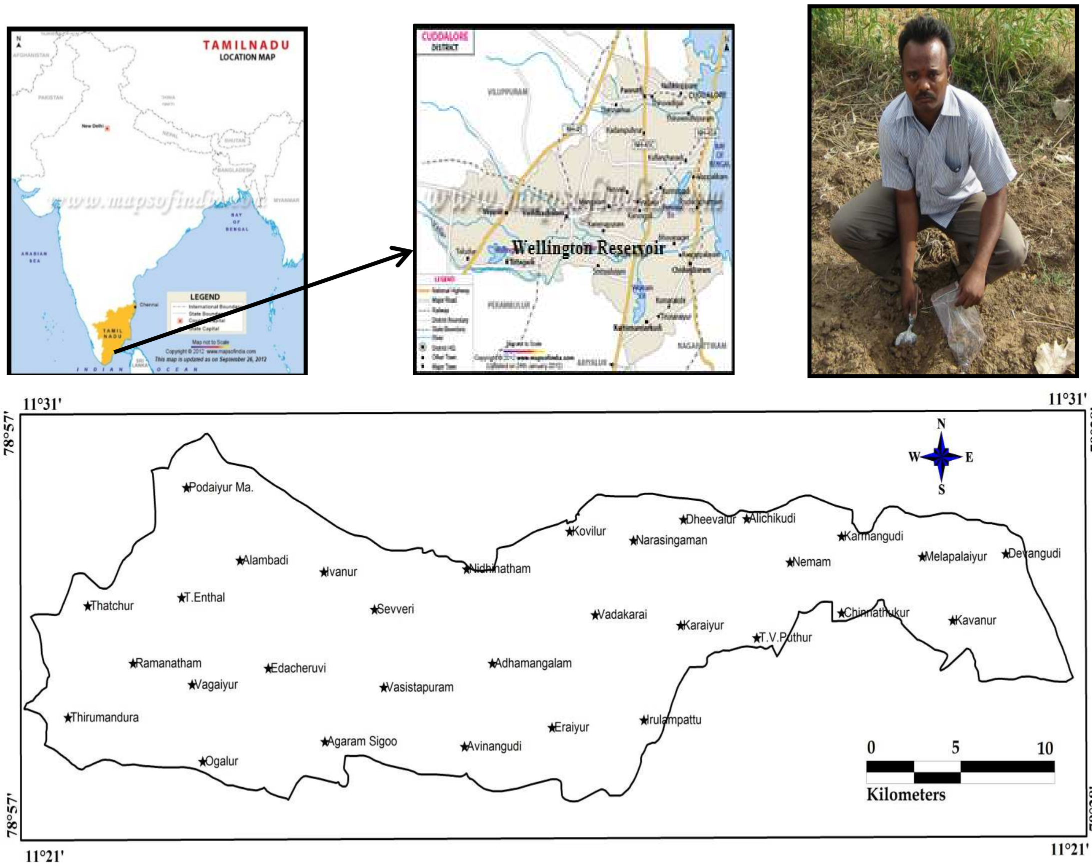

Fig.1. Location map of the study area

IV. RESULTS AND DISCUSSION

pH and EC

It was observed that soil *p*H varied from 6.9 to 8.3 with an average 7.57. According to classification of soil reaction suggested by Brady (1985) (Table 1, 2), 6 samples were neutral and Moderately Alkaline (6.6 – 7.3), 19 samples were slightly Alkaline (7.4 – 7.8), 5 samples were moderately alkaline (7.9 – 8.4), in reaction which comprises to 0, 0, 18.92, 64.86 and 16.22%, respectively. The neutral to alkaline pH may be attributed to the reaction of applied fertilizer material with soil colloids, which resulted in the reaction of basic cation on the exchangeable complex of the soil (Singh and Mishra 2012).The electrical conductivity varied from 0.12 to 2.3 dS m^{-1}, with a mean value of 1.21dS m^{-1}. On the basis of limits suggested by Muhr *et al*. (1963) for judging all soil samples were found in normal range. Due to high precipitation (1500mm) and less evaporation demand, the salt accumulation is not

prevalent in this region, which is suitable for crop growth.

Nitrogen

Available nitrogen status varied from 21mg kg^{-1} to 140 mg $kg^{-1}$with an average value of 92.69 mg kg^{-1}. On the basis of the ratings suggested by Subbiah and Asija (1956), 81.08% of the samples were found to be low (250kg/ha) and remaining % of the samples were found to be medium (250-500kg/ha). Low nitrogen status in the soils could be due to low amount of organic carbon in the soil. Since most of the soil nitrogen is found in organic form. Since most of the soil nitrogen found in organic form, therefore, this relationship was observed. Available nitrogen was less positively correlated (r=0.245) with pH. Similar result was also reported by Verma et al (1980).

Phosphorus

The available phosphorus content varied from 7.5 kg/ha to 25 kg/ha with an average of 16.25 kg/ha on the basis of the limits suggested to Muhr et al.(1963), most of the soil samples (45.95%) were low (20 P_2O_5 kg/ha) in available phosphorus status and rest were under medium (20-50 kg/ha) category. A poor positive correlation (r=0.062) was observed between electrical conductivity and available phosphorus (Table 2). This indicates that presence of increases the availability of phosphorus in soil. According to Tisdale et al. (1997), about 50% of phosphorus is found in organic form and decomposition of organic matter produces humus which forms complex with Al and Fe and protected with P fixation.

Zinc and Copper

The available zinc varied from 0.79–3.12 mg $kg^{-1}$with the mean value of 1.96 mg kg^{-1} (Table 1, 2). Only zero present were found in deficient range, by considering 0.6 mg kg^{-1}as the critical limits of zinc suggested by Takkar and Man (1975). 10.81, 56.76 and 32.43 percent soils were found in marginal, sufficient and higher range (Fig 1). Available copper content ranged from 0.64 – 9.26 with mean value of9.9 mg kg^{-1} (Table 1, 2). Zero percent were found in deficient range, by considering 0.2 mg kg^{-1}as critical limit for copper deficiency (Lindsay and Norvell 1978). Zero percent were found in marginal range and also 100 percent were found in sufficient range.

Iron

Available Fe content in the soil ranged from 2.52 – 34.66 with mean value of 18.59 mg kg^{-1}(Table 1 & 2). Only 18.92 percent was found in deficient range, 24.32 percent were found in marginal range and rest of the soils has sufficient amount of available Fe considering 4.5 mg kg^{-1} as a critical limit suggested by Lindsay and Norvell (1978).

Manganese

Available Mn in the studied soils varied from 4.05 – 21.44 mg $kg^{-1}$with mean value of 12.75 mg kg^{-1}. Considering 1.0mg kg^{-1}as a critical limit for Mn deficiency (Lindsay and Norvell 1978), only zero percent was found in deficient and marginal range, and rest of the soils has sufficient amount of available Mn (Fig 1). The variations observed in available

micronutrient among different soils might be the result of variable intensity of different pedogenic processes taking place during soil development. Decomposition of organic material release micronutrient and also reduces pH locally which assists in mineral solubility. Further availability of metal ions (Zn, Cu, Fe and Mn) increases as the organic matter provides chelating agent for complexation of these micronutrients. Thus management of carbon stocks (FYM, night soil, organic residues, etc.) will improve their availability to the plants.

Table1. Criteria for assessment of soil chemical characteristics

parameters	**Range**	**Mean**			
pH	6.9 – 8.3	7.6			
EC	0.12 – 2.3	1.21			
Available Macronutrients	**Range (kg/ha)**	**Mean (kg/ha)**	**Low (%)**	**Medium (%)**	**High (%)**
N	21 – 140	80.5	81.08	18.92	-------
P	7.5 – 25	16.25	-------	45.95	54.05
K	62.5 – 90	15.25	-------	100.00	-------
Available Micronutrients	**Range (mg/ha)**	**Mean (mg/ha)**	**Deficient (%)**	**Marginal (%)**	**Sufficient (%)**
Fe	2.52 – 34.66	18.59	18.92	24.32	56.76
Mn	4.05 – 21.44	12.75	0	0	100
Cu	0.64 – 9.26	9.9	0	0	100
Zn	0.79 – 3.12	1.96	0	10.81	89.19

Table 2. Correlation analysis of Soil samples

	EC	**pH**	**N**	**P**	**K**	**Zn**	**Cu**	**Fe**	**Mn**
EC	1.000								
pH	-.515	1.000							
N	-.022	.245	1.000						
P	.062	-.069	.252	1.000					
K	.254	-.151	.183	-.299	1.000				
Zn	-.045	-.084	-.007	.178	-.077	1.000			
Cu	-.128	.083	.058	.050	-.002	-.288	1.000		
Fe	.025	.045	.178	-.223	.046	.071	.063	1.000	
Mn	-.176	-.212	-.109	-.239	-.007	-.118	.149	.562	1.000

Table 3. Physico-Chemical properties and Nutrient Status of soil characteristics (Kirmani *et al*. 2011)

pH	Mohr's Scale Range	Zinc Range	Status	Copper Range	Status	Iron Range	Status	Manganese Range	Status
5.5-6.0	Acidic	<0.6	Deficit	< 0.2	Deficit	< 4.5	Deficit	< 2.5	Deficit
6.1-6.5	Sl. Acidic	0.6-1.2	Marginal	0.2-0.4	Marginal	4.5-9.0	Marginal	2.5-3.5	Deficit
6.6-7.3	Neutral	1.2-2.4	Sufficient-I	0.4-0.8	Sufficient-I	9.0-18.0	Sufficient-I	3.5-7.0	Marginal
7.4-7.8	Sl. Alkaline	>2.4	Sufficient-II	0.8-1.6	Sufficient-II	18.0-27.0	Sufficient-II	> 7.0	Sufficient-II
7.9-8.4	Mod. Alkaline			1.6-3.2	Sufficient-III	> 27.0	Sufficient-III		

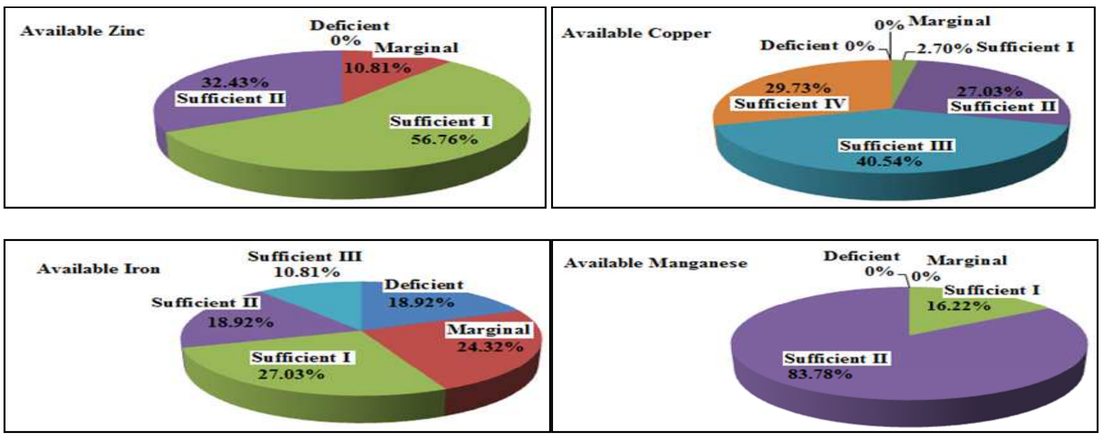

Fig 2. Physico-chemical and nutrient status of Wellington Reservoir

Relationship between Electrical Conductivity, pH and Macronutrient status of soil

Available N, P, K – Simple correlation studies of available nitrogen, phosphorus and potassium with pH of soil samples shows no relationship with nitrogen but with phosphorus and potassium have less negative relationship. Less negative correlation of electrical conductivity was found with available nitrogen (r = -0.022) and phosphorus (r = 0.062) and potassium was positive but not significant correlation (r = 0.254). It was observed that available phosphorus potassium did not show any correlation with $CaCO_3$ content of soil.

Relationship between Electrical Conductivity, pH and Micronutrient status of soil

Available Fe - Correlation studies between available Fe and electrical conductivity of soil showed less degree positive relationship (r = 0.025). Poor positive correlation of Fe with pH was found (r = .045). Available Mn – poor negative

correlation was found between available Mn and electrical conductivity (r = -0.176). Negative correlation (r = - 0.212) was found between Mn and pH. Available Zn- Available Zn content in soil showed poor negative correlation (r = -0.045) with electrical conductivity of soil. There was poor negative correlation (r = -0.084) between available Zn and pH of soil. Available Cu - There was poor positive but not significant correlation (r = 0.083) of available Cu with pH of soil. But poor negative correlation (r =-0.128) was found between available Cu and electrical conductivity of soil. Similar findings about relationship between available micro-nutrients, pH and electrical conductivity of soil were reported by Kumar and Babel (2011) and Chaudhari *et al*. (2012).

CONCLUSIONS

From this study, the following conclusions can be made for the soil of Tittakudi taluk (Tamilnadu state).

1. Concept of soil macro and micronutrients of study area were found in category of low fertility status for nitrogen, phosphorus and potassium. Among the four micronutrients available Fe, Cu and Mn were sufficiently present in all the soil samples. In 16 villages Fe was found to be deficient and marginal. Fe deficiency leads to widespread marginal nutritional disorder in sugarcane crops. In case of field crops, soil application of $FeSO_4$ @125 kg/ha can be done before showing or transplanting. Foliar sprays of 0.5% $FeSO_4$ 2-3 times at 10-15 days interval can be effective in correcting Fe deficiency in standing crops. Further application of Fe along with organic manures may enhance the availability and efficiency of native Fe through chelation.
2. Considering the critical limit of macro-nutrients, the recorded macronutrients are 81.08% low, 18.92% medium in nitrogen, 45.95% medium in phosphor-rous and 54.05% medium in potassium. Among micronutrients, Fe sufficient by 56.76%, Mn sufficient by 100%, Zn sufficient by 89.19% and Cu sufficient by 100%. The studied soils though contained adequate amounts of available micronutrients deficiencies also recorded. The results indicated that the soil properties pH, EC, Organic Carbon as the main characteristics playing major role in controlling the availability of micronutrients. These factors could be manipulated in order to combat any present or future deficiencies of micronutrients in these soils.
3. Less negative correlation of electrical conductivity was found with available nitrogen (r =-0.022) and phosphorus (r = 0.062) and potassium (r =0.254) was positive but not significant correlation. It was observed that available phosphorus potassium did not show any correlation with CaCO3 content of soil.
4. Less degree negative correlation of electrical conductivity with available micronutrients of Manganese, Zinc and Copper but poor positive correlation of iron in soil was observed.

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